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14. ABSTRACT This slide presentation assesses the degree to which various types of engineered source-reduction efforts at selected fuel-contaminated sites have resulted in decreasing concentrations of fuel constituents dissolved in groundwater and describes a methodology for evaluating the potential effectiveness of source-reduction actions at reducing the magnitude and extent of dissolved fuel constituents.					
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Source Reduction Effectiveness Technical Summary Report

Presented by
John R. Hicks



Parsons

Parsons Engineering Science, Inc.

Presentation Outline

- **Project Objectives and Site Locations**
- **Statistical Tools**
- **Case Histories**
- **Summary and Conclusions**

Project Description and Objectives

- **Assess the degree to which various types of engineered source-reduction efforts at selected fuel-contaminated sites have resulted in decreasing concentrations of fuel constituents dissolved in groundwater; and**

Project Description and Objectives

- **Describe a methodology for evaluating the potential effectiveness of source-reduction actions at reducing the magnitude and extent of dissolved fuel constituents**

Source Reduction Sites

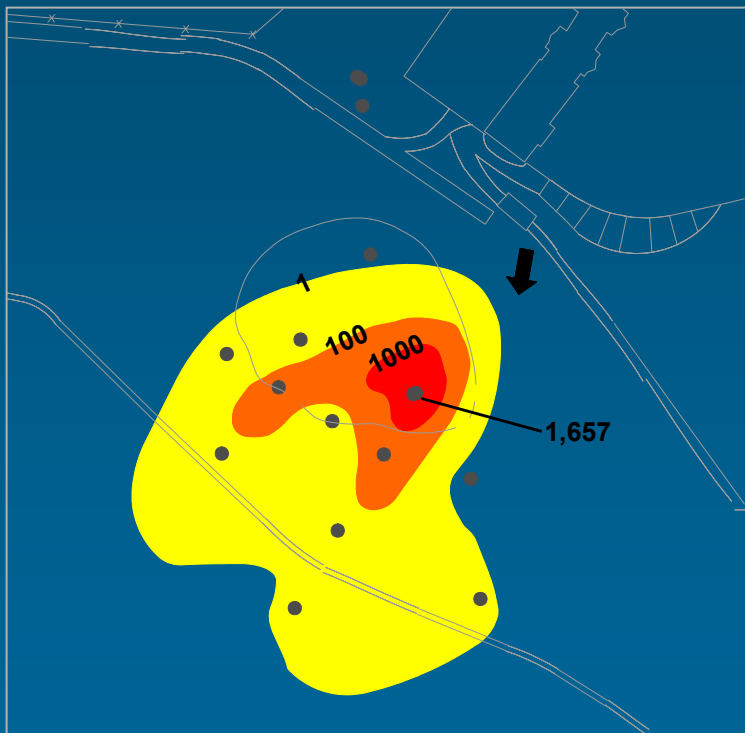


Statistical Tools

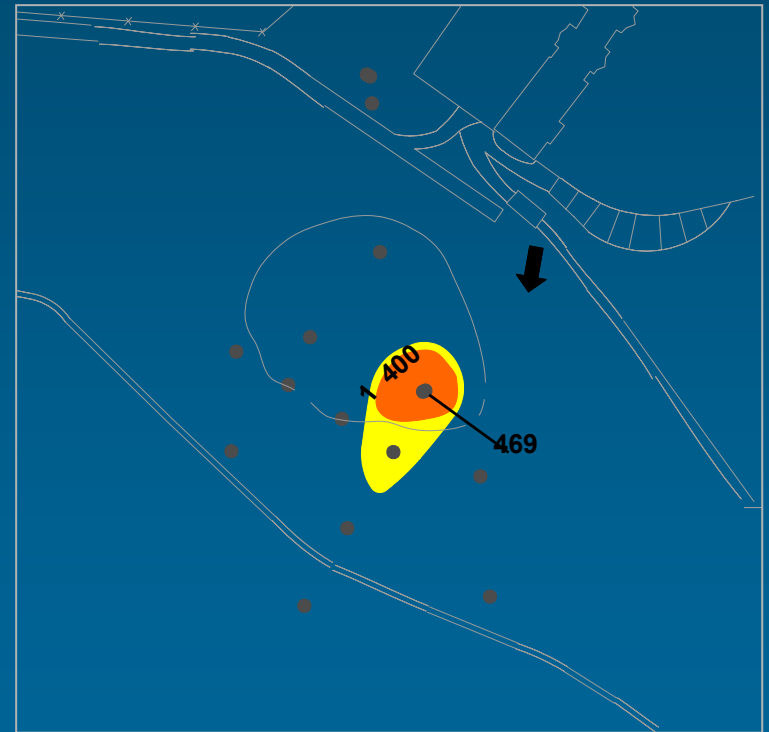
- **Mann-Kendall Test for Trend**
 - nonparametric
 - non-detects can be used
 - requires only small sample sizes
- **Sen's Nonparametric Estimator of Slope**
 - not greatly affected by outliers
 - magnitude of slope is indicator of rate of change

BTEX in Groundwater

Site FT-03, Westover AFB, MA



May 1975

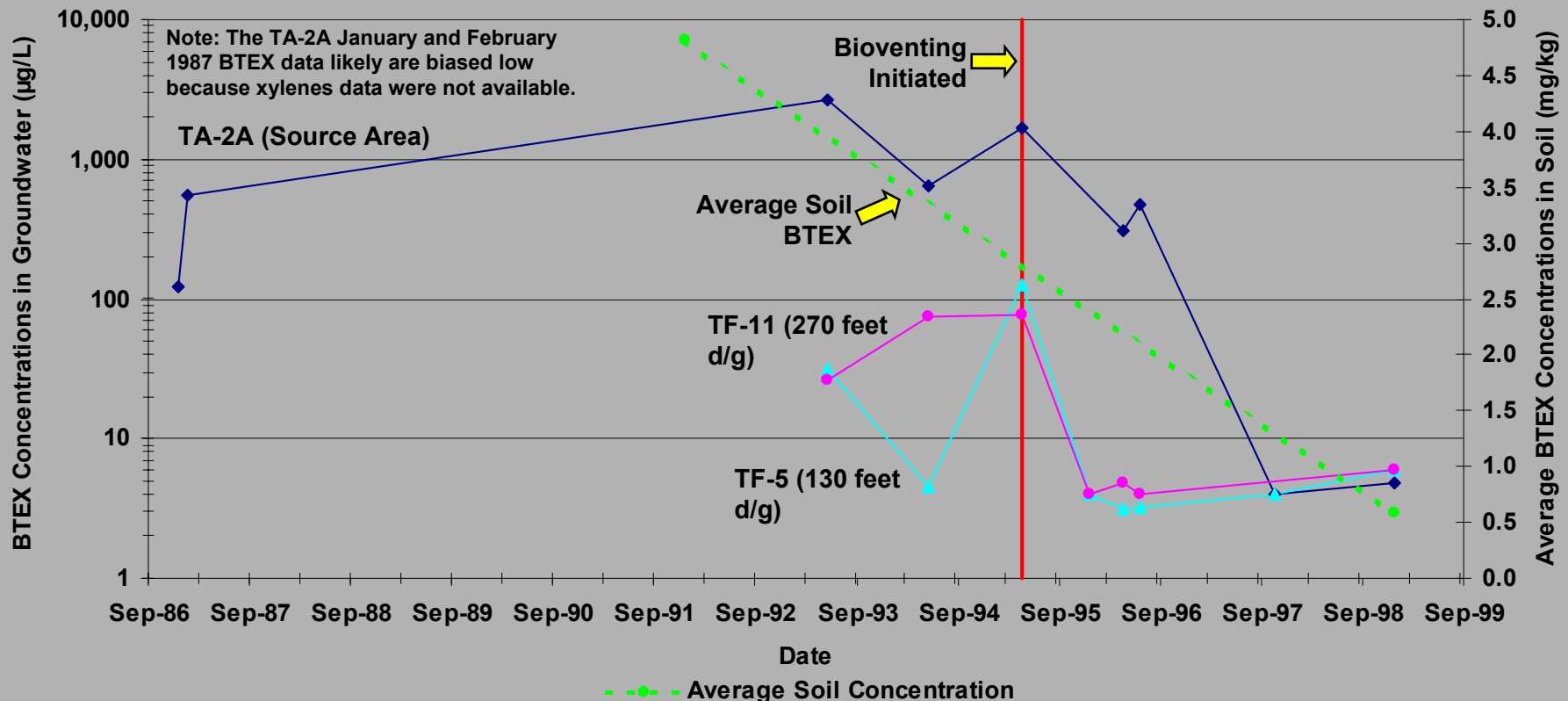


July 1996

■ >1000 µg/L ■ 100-1000 µg/L ■ 1-100 µg/L

BTEX Concentrations in Groundwater and Soil

Site FT-03 - Westover AFB, MA



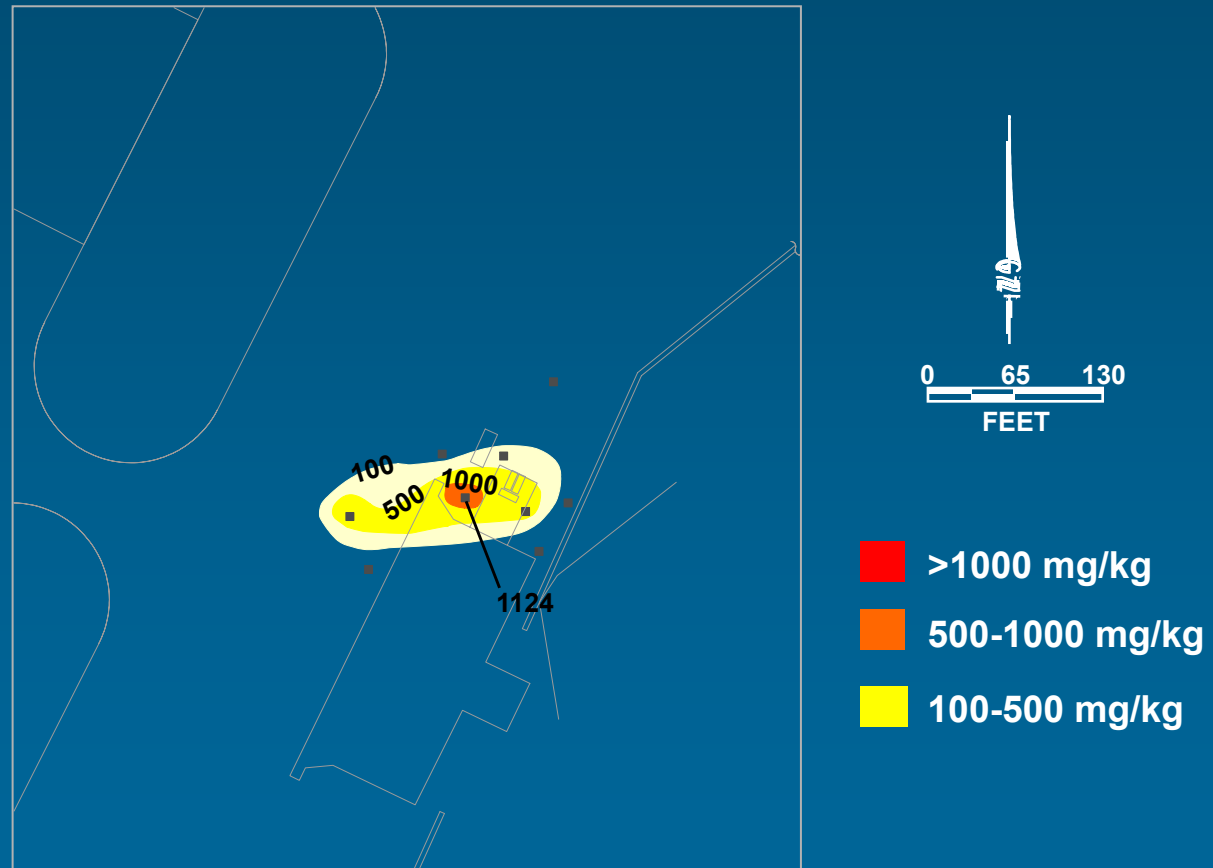
Statistical Summary for BTEX

Site FT-03 - Westover AFB, MA

<i>Well Location</i>	<i>Pre-Remed MK</i>	<i>Post-Remed MK</i>	<i>Pre-Remed Slope</i>	<i>Post-Remed Slope</i>	<i>Pre-Remed BTEX μg/L</i>	<i>Most recent BTEX μg/L</i>
Source	-1	-6	-520	-323	1,657 (0.0 yr)	4.9 (3.7 yr)
130 feet d/g	1	0	46	0	124 (0.0 yr)	6 (3.7 yr)
270 feet d/g	3	-1	25	-0.4	77 (0.0 yr)	<6 (3.7 yr)

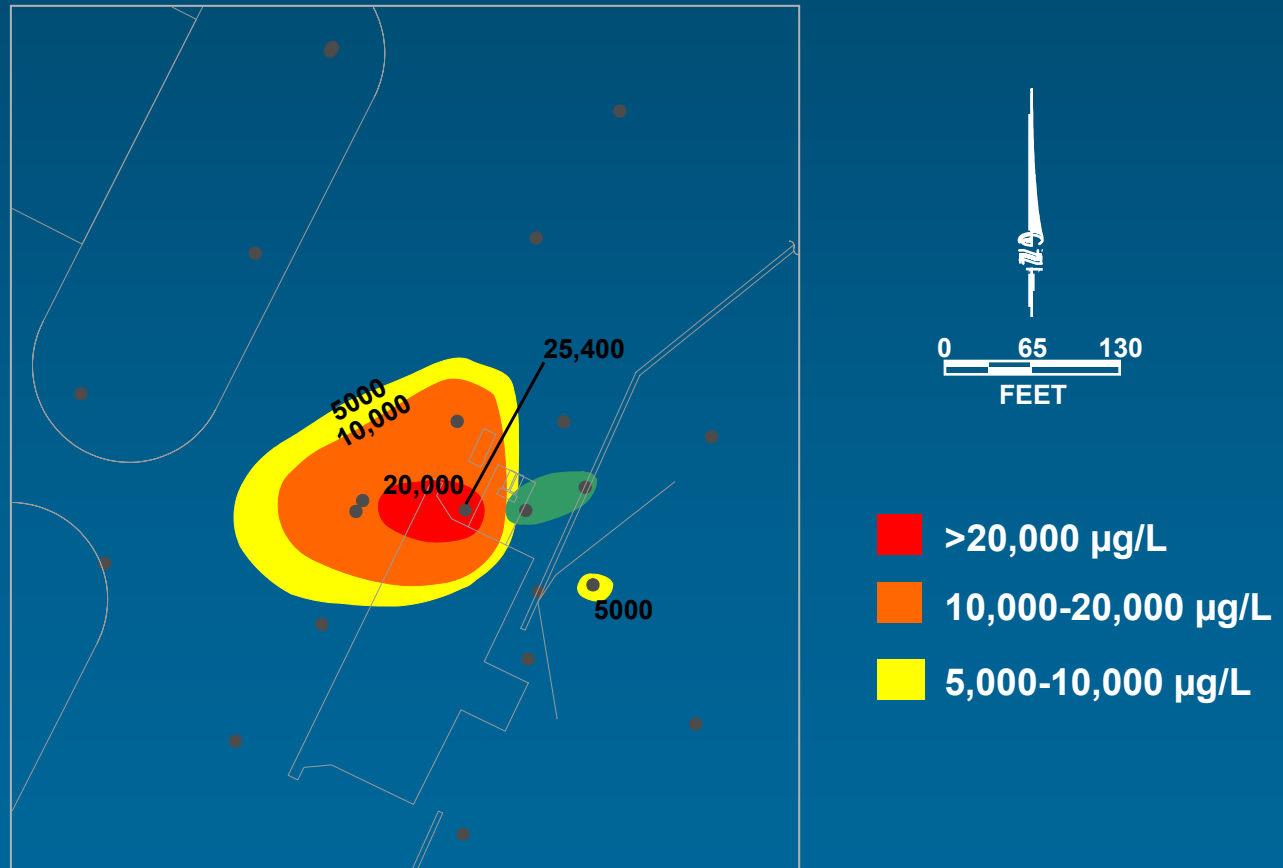
Soil BTEX Concentrations, 4'-6' BGS

Site ST-27, Charleston AFB, SC



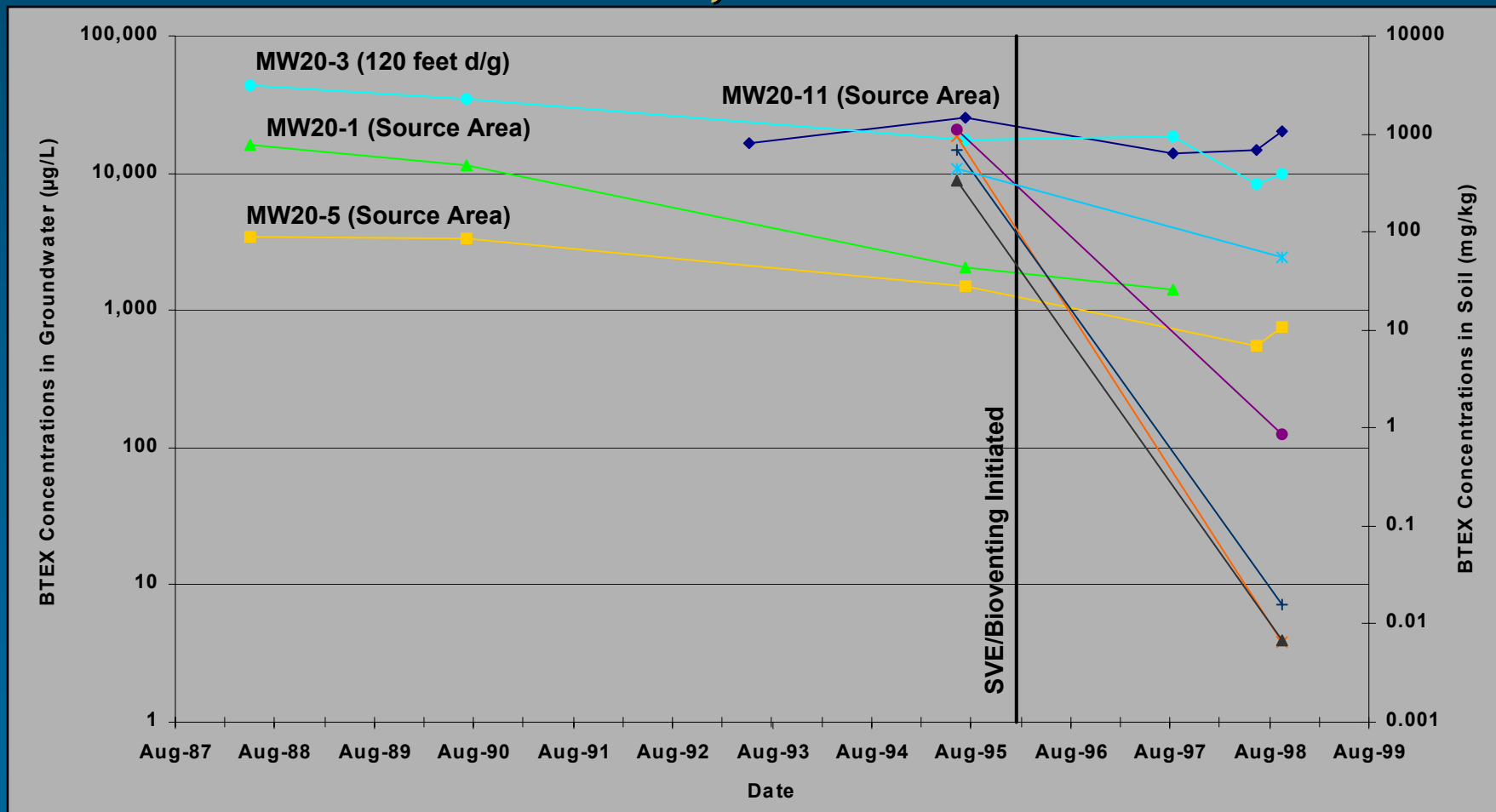
BTEX in Groundwater, 1995

Site ST-27, Charleston AFB, SC



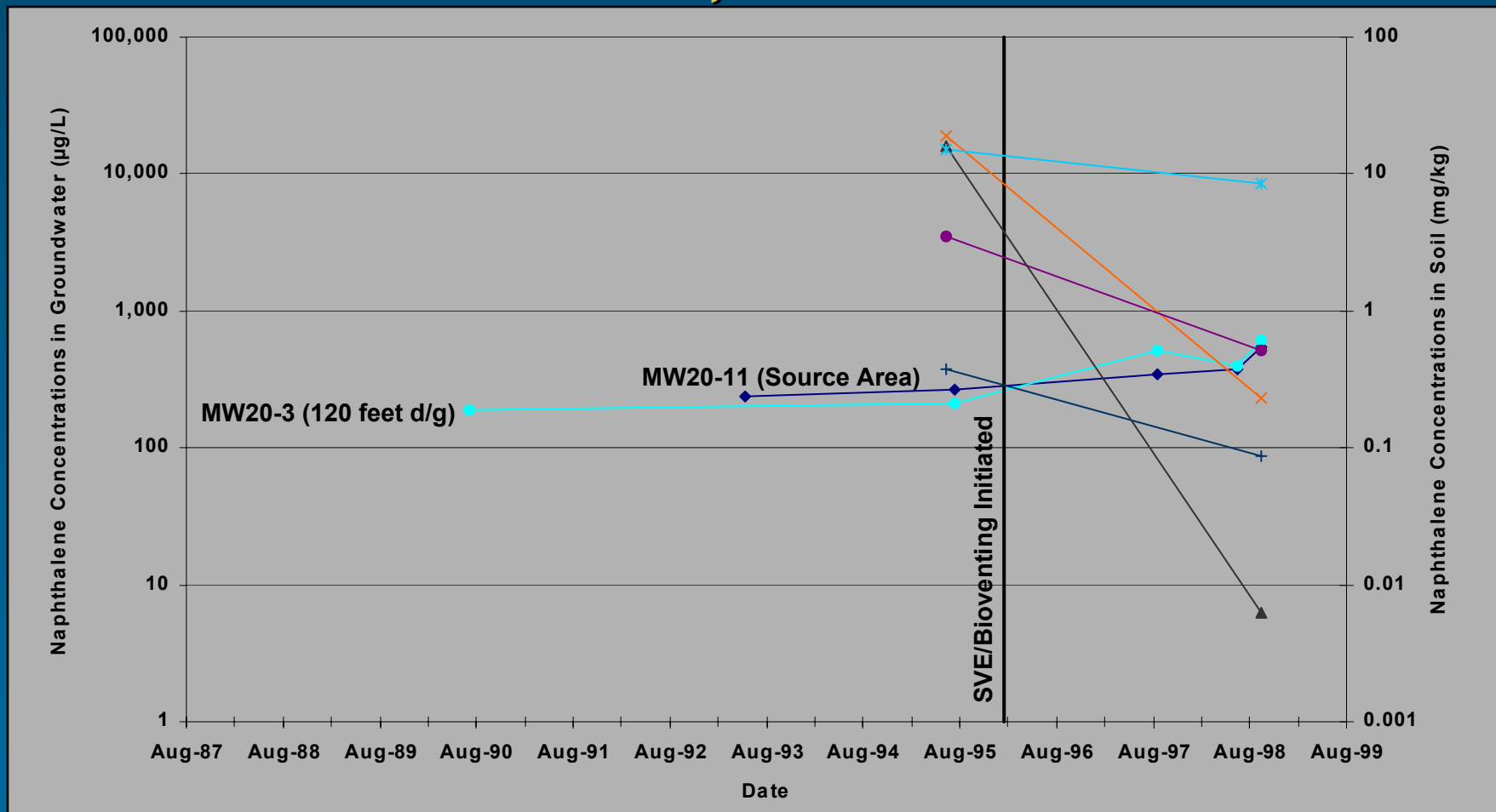
BTEX Concentrations in Groundwater and Soil

Site ST-27 - Charleston AFB, SC



Naphthalene Concentrations in Groundwater

Site ST-27 - Charleston AFB, SC



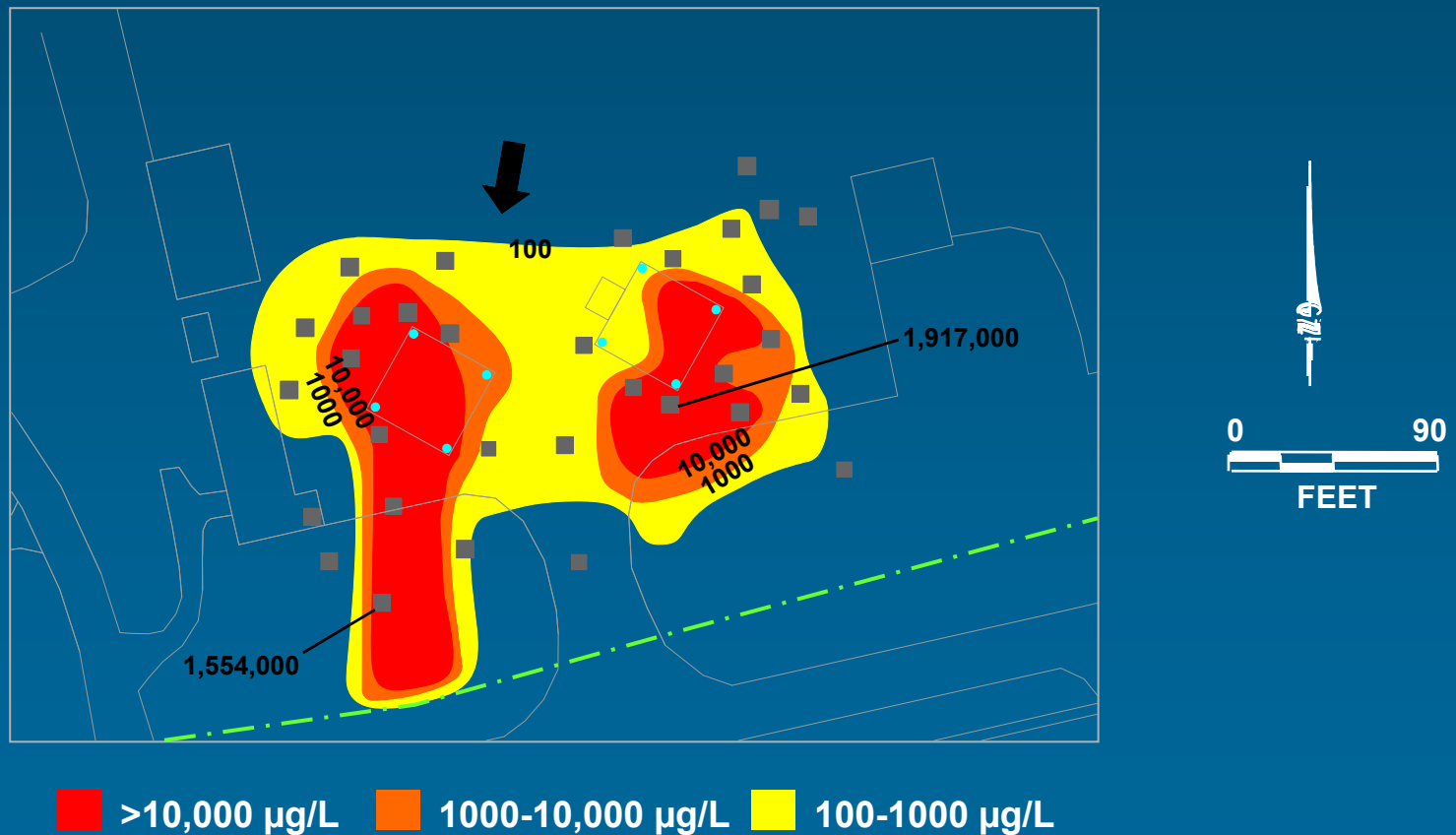
Statistical Summary for BTEX

Site ST-27 - Charleston AFB, SC

Well Location	Pre-Remed MK	Post-Remed MK	Pre-Remed Slope	Post-Remed Slope	Pre-Remed BTEX $\mu\text{g/L}$	Most recent BTEX $\mu\text{g/L}$
Source	-3	-1	-971	-368	1,481 (0.5 yr)	746 (2.7 yr)
120 feet d/g	-3	-2	-13,065	-3,372	17,500 (0.5 yr)	9,888 (2.7 yr)

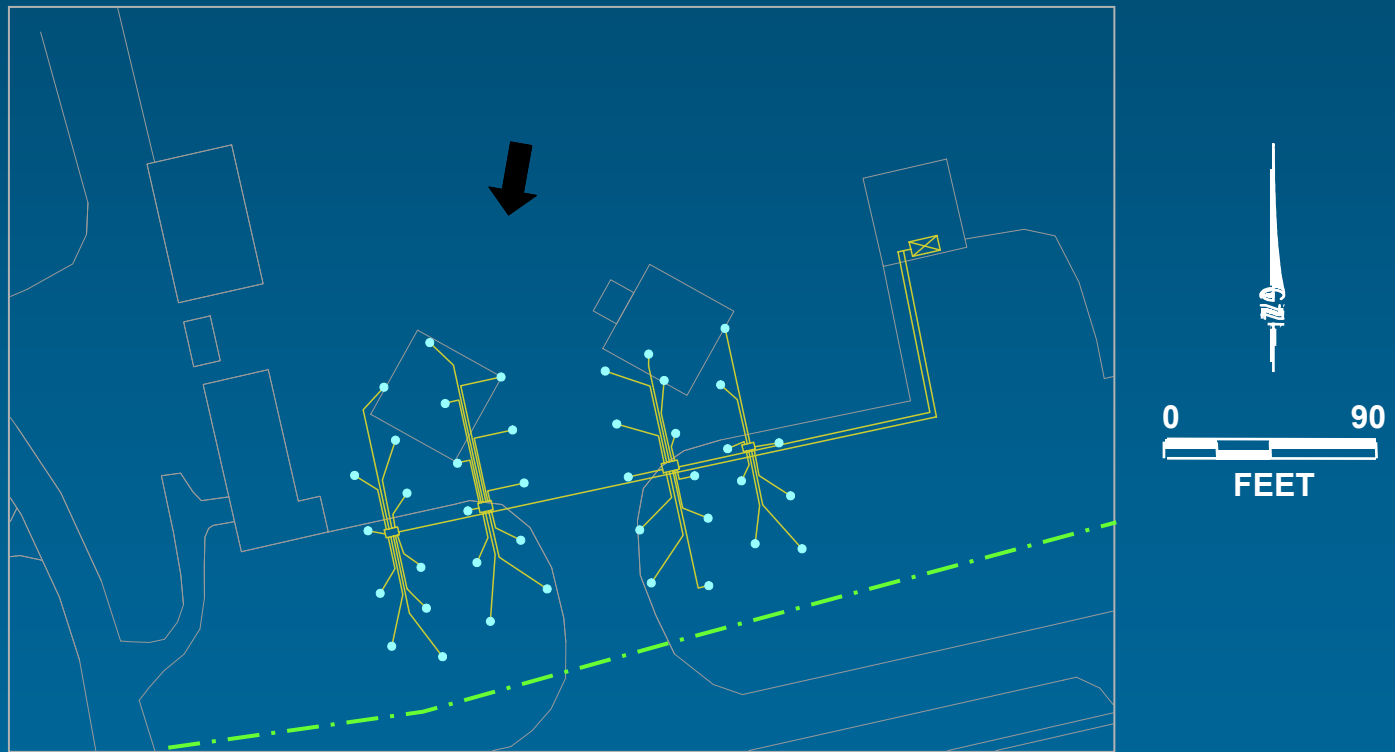
Soil BTEX Concentrations - 1988-1995

MOGAS Site - Myrtle Beach AFB, SC



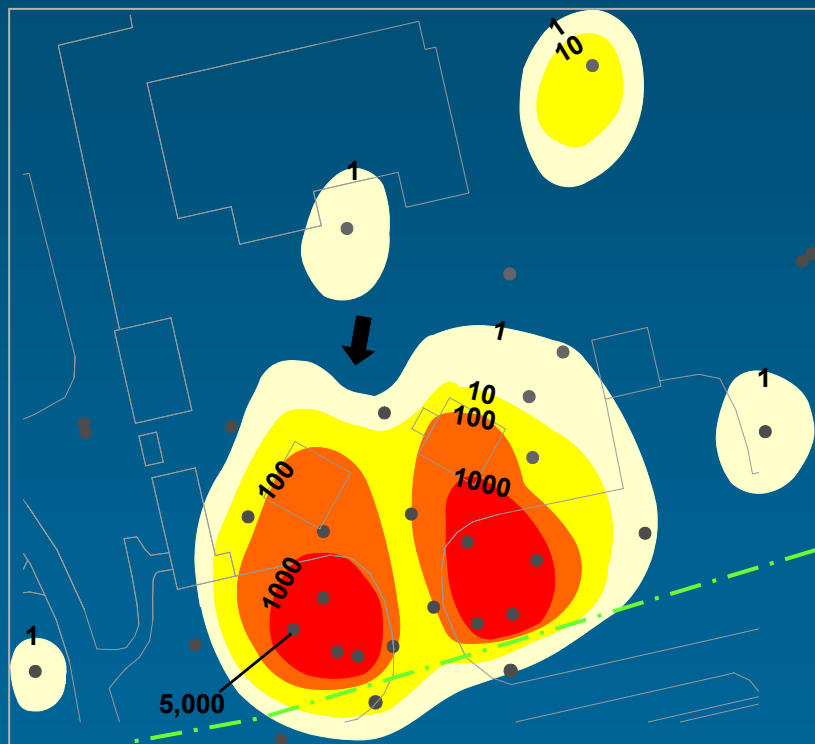
Air Sparging System Layout

MOGAS Site - Myrtle Beach AFB, SC

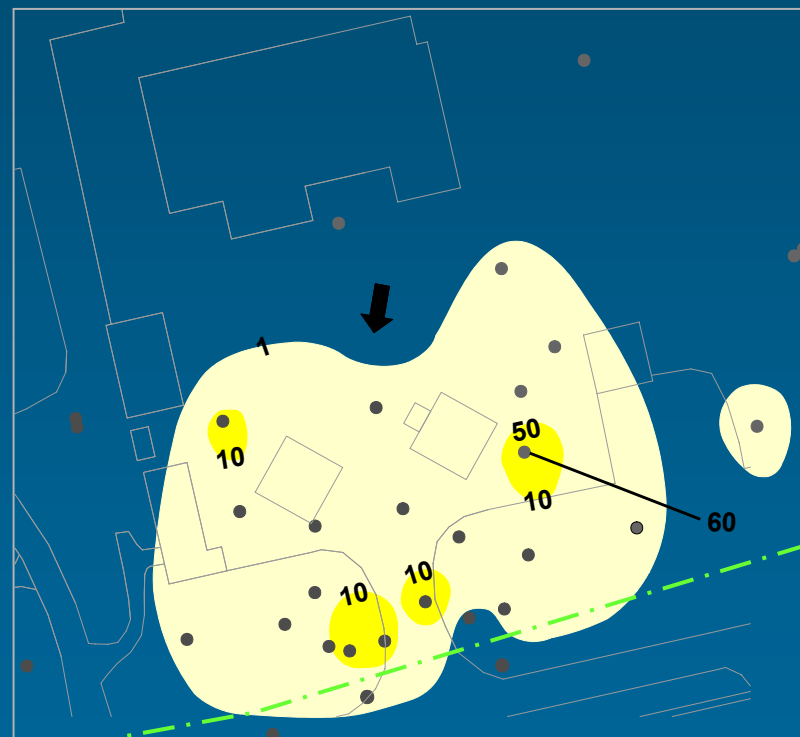


Benzene in Groundwater

MOGAS Site - Myrtle Beach AFB, SC



August/September 1995



August/October 1999

>1000 µg/L

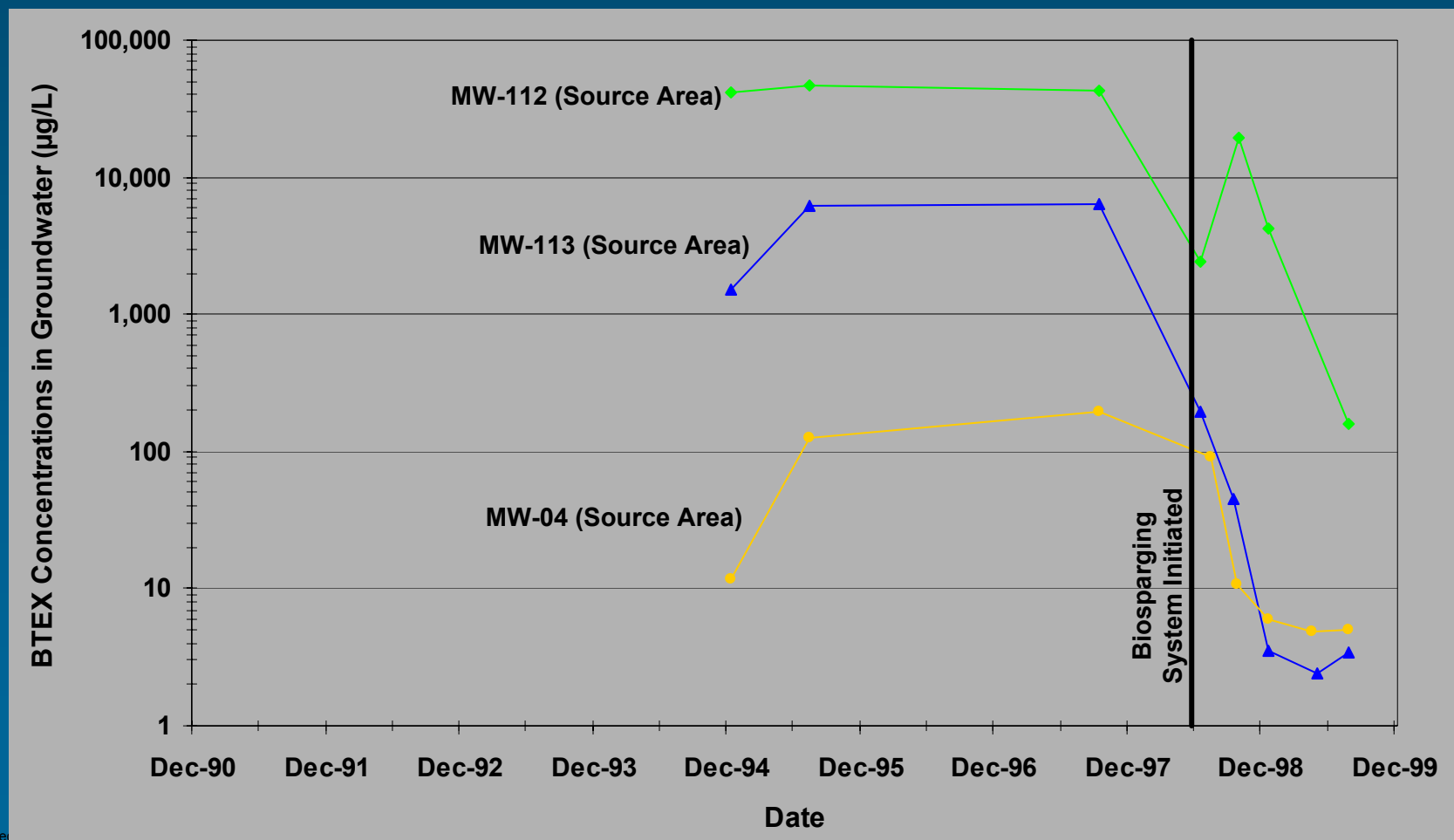
100-1000 µg/L

10-100 µg/L

1-10 µg/L

BTEX Concentrations in Groundwater

MOGAS Site - Myrtle Beach AFB, SC



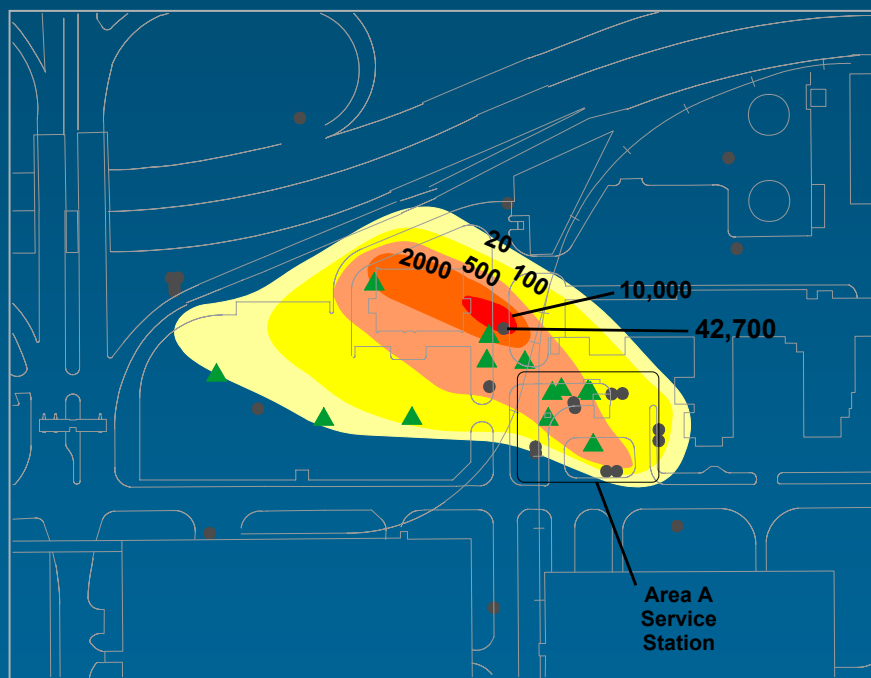
Statistical Summary for BTEX

MOGAS Site - Myrtle Beach AFB, SC

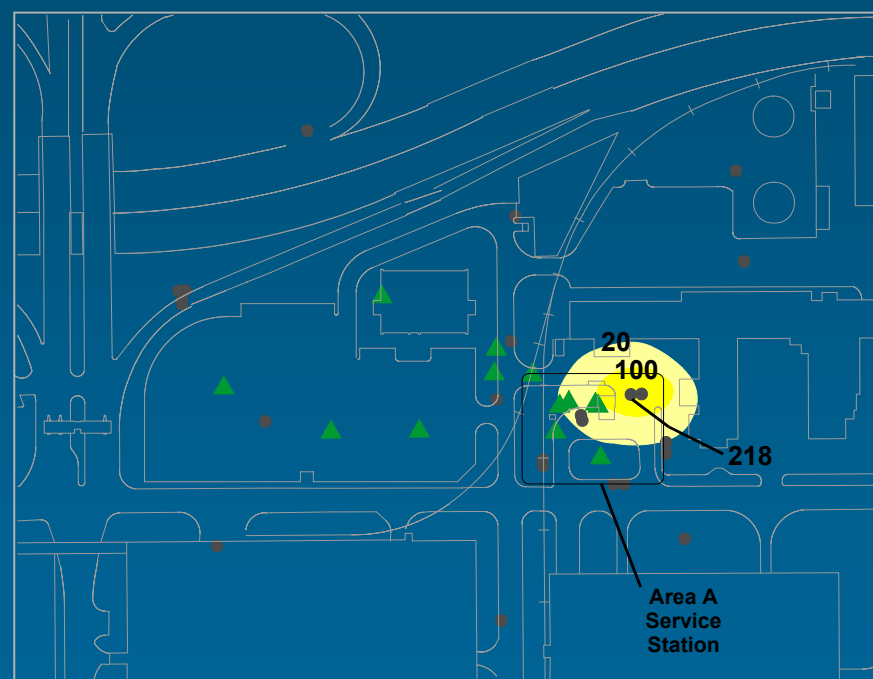
Well Location	Pre-Remed MK	Post-Remed MK	Pre-Remed Slope	Post-Remed Slope	Pre-Remed BTEX $\mu\text{g/L}$	Most recent BTEX $\mu\text{g/L}$
Source	1	-2	498	-2,422	43,100 (0.5 yr)	160 (1.3 yr)
Source	3	-8	2,424	-32	6,380 (0.5 yr)	3 (1.3 yr)
Source	3	-8	91	-4	194 (0.5 yr)	5 (1.3 yr)

BTEX in Groundwater

Area A Service Station - Tinker AFB, OK



May 1997

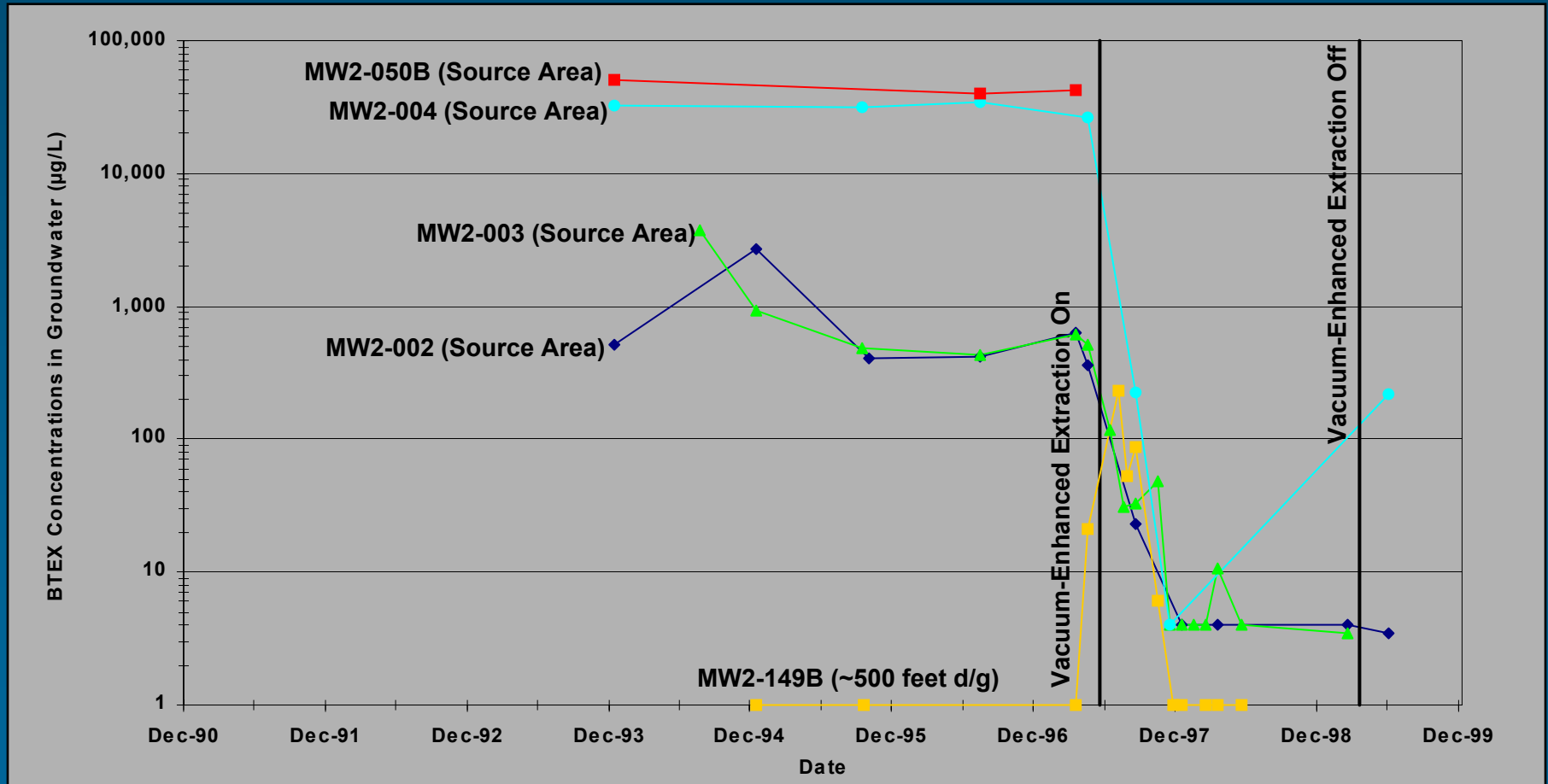


March/June 1999



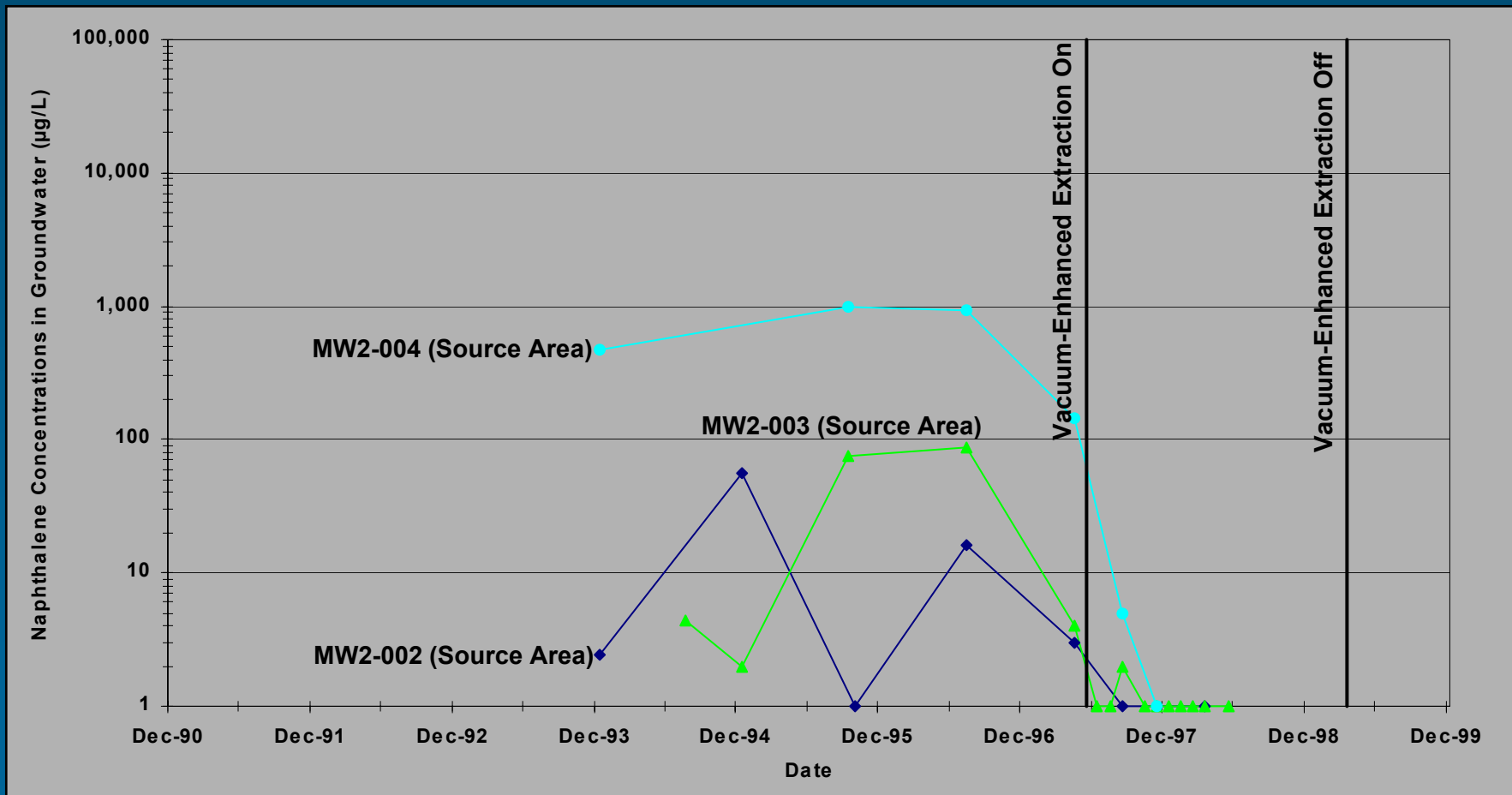
BTEX Concentrations in Groundwater

Area A Service Station - Tinker AFB, OK



Naphthalene Concentrations in Groundwater

Area A Service Station - Tinker AFB, OK



Statistical Summary for BTEX

Area A Service Station - Tinker AFB, OK

Well Location	Pre-Remed MK	Post-Remed MK	Pre-Remed Slope	Post-Remed Slope	Pre-Remed BTEX $\mu\text{g/L}$	Most recent BTEX $\mu\text{g/L}$
Source	-2	-4	-1,925	-4,433	26,150 (0.1 yr)	217 (2.2 yr)
Source	-5	-3	-33	-178	359 (0.1 yr)	4 (2.2 yr)
20 feet d/g	-7	-9	-101	-42	618 (0.1 yr)	4 (1.9 yr)

Summary and Conclusions

- **Careful site characterization prior to selection of remedial method**
- **Borehole advancement below the water table**
- **Assessment of smear zone thickness**

Bioventing and SVE

- **Primary factor = smear zone presence**
- **Smear zone persistence = plume persistence**
- **Mounding of water table at SVE sites**
- **Charleston AFB Site ST-27--less effective**

Biosparging

- **Potential for smear zone remediation**
- **Sandy, homogeneous soils**
- **Rapid decreases of dissolved BTEX with depth**
- **Well spacing \leq 20 feet**
- **Myrtle Beach AFB - rate increase of 101-586%**

Vacuum-Enhanced Extraction

- **Aggressive method**
- **Thin saturated zones**
- **Low- to moderate-permeability soils**
- **Presence of free product**

Vacuum-Enhanced Extraction

- **Dewatering of smear zone**
- **Tinker AFB Area A success**
- **130 to 439 % increase in BTEX removal rates**

Excavation

- **Effectiveness on dissolved contamination
function of thoroughness of excavation**
- **Excavation below the water table can be
problematic**
- **Mixed success at Travis AFB N & S Gas
Stations**

Additional Fuel Compounds

- **Naphthalene**
- **MTBE**

Naphthalene

- **Source reduction less effective**
- **Charleston AFB**
 - **increasing concentrations following SVE/Bioventing**
- **Eglin and Myrtle Beach AFBs**
 - **75 to 99 % slower than BTEX reductions**

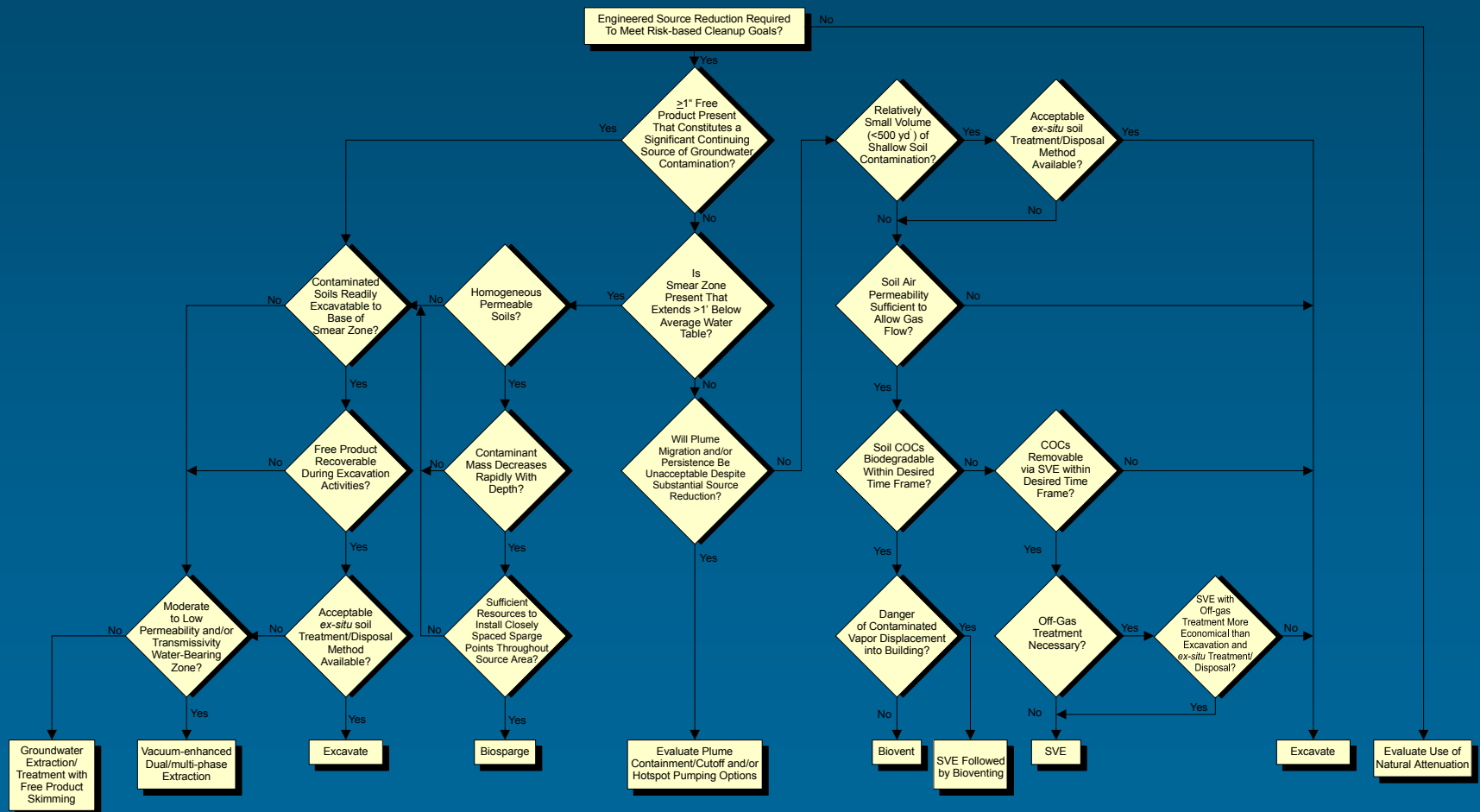
Naphthalene

- **Lower volatility**
- **More recalcitrant to biodegradation**
- **Higher degree of sorption**
- **More success at Tinker AFB Area A**

MTBE

- Travis AFB
 - 54 to 95 % slower than BTEX reductions
- Vadose zone source removal less likely to cause rapid reductions in dissolved concentrations
- Can be relatively recalcitrant
- Quickly leaches from soil

Methodology for Selecting an Engineered Source Reduction Technique



Methodology for Selecting an Engineered Source Reduction Technique

